THE RED BEDS BETWEEN WICHITA FALLS, TEXAS, AND LAS VEGAS, NEW MEXICO, IN RELATION TO THEIR VERTEBRATE FAUNA

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During the summer of 1912 the author traveled by wagon from the north line of Oklahoma, south along the contact of the Pennsylvanian limestones and the Red Beds, to near Purcell and then west to the Wichita Mountains; from there the party turned south to Wichita Falls, Texas, and then west across the Staked Plains and eastern New Mexico to Las Vegas. It is the portion of the trip from Wichita Falls to Las Vegas that is described in this paper.

Active work during recent years has resulted in abundant collections from the Permian or Permo-Carboniferous beds of Texas and New Mexico, and we have now a fair knowledge of the most common fossil vertebrates. New forms will undoubtedly be found and additional information gained as to the habits and structure of forms already partially known, but enough information is at hand to warrant an attempt to determine the habitat and distribution of the fauna as a whole. The work of the expedition was directed toward determining (1) the limits, both geographical and geological, of the vertebrate-bearing beds in Texas and New Mexico, and (2) the character of the beds as revealing information of the habits and habitat of the creatures.

Vertebrate fossils of Permian or Permo-Carboniferous age have been found in Cowley County, southern Kansas, in a north-south strip through central Oklahoma, in north-central Texas, and in north-central New Mexico. In Kansas, fossils have been found in only one locality and there only in the excavation of a well located at the bottom of a ravine; no exposure of bone-bearing beds has been found. In Oklahoma, fossils have been found in Kay, Grant, Noble, and Logan counties, and south of the Wichita Mountains, all in the Enid formation, but others will undoubtedly be found

wherever the Enid occurs. The lack of exposure and the abundant vegetation make their discovery a matter of great difficulty. In Texas, fossils occur in Wichita, Archer, Baylor, and Willbarger counties, and a few fragments of bone have been reported by Cummins as far south as the southern line of Haskell County, all in the Wichita and Clear Fork formations.

The Texas beds have yielded by far the greater number of vertebrate fossils and are regarded as the type locality; the relation of these beds to those of Oklahoma and New Mexico is still uncertain. On the east the Texas beds shade into the Cisco limestone as shown by Cummins and Gordon and on the west they disappear beneath the Dockum beds of Triassic age, on the eastern edge of the Staked Plains. On the western side of the Staked Plains Red Beds again appear and can be traced nearly to the edge of the Rocky Mountains, but for some distance east of the mountains they are covered, in the latitude of Las Vegas, by Cretaceous.

In attempting to answer the first question mentioned above, it was necessary to trace the Red Beds from their easternmost appearance to the edge of the mountains. The route followed was west from Wichita Falls through Seymour, in Baylor County, Haskell, Haskell County, Spur, Dickens County, Crosbyton, Crosby County, north through Floyd, Motley, and Briscoe counties to Clarendon, and then approximately along the line of the Fort Worth & Denver City Railroad to Amarillo and along the Chicago, Rock Island & Gulf Railroad to Tucumcari and Montoya. At Montoya the party left the railroad and headed for Las Vegas along the foot of the high mesa to the head of the Conchas River and then over the mesa to Las Vegas Hot Springs. The return route was across northeastern New Mexico to Clayton and then through the No Man's Land of Oklahoma to Alva where the party broke up.

Near Wichita Falls the surface rocks belong to the Wichita and Clear Fork formations already described in more or less detail by Cummins, Case, and Gordon.[1] On the east the Wichita beds shade into the Pennsylvanian limestone just as the Enid does to

[1] Cummins, *Second Annual Report, Geological Survey of Texas;* Case, *Bull. American Museum Natural History,* XXIII; Gordon, *Jour. Geol.,* XIX.

the north in Oklahoma;[1] this shows that there was to the east an open sea whose eastern limits cannot be determined as the deposits have been removed by erosion. The Wichita is composed largely of sandstones, sometimes heavily bedded, and red and blue clays sometimes with irregular shaly sandstones and local conglomerates. The Clear Fork to the west is characterized by layers of impure and dolomitic limestone distributed through a considerable thickness of irregular beds of sandstone, shale, and clay, mostly of a red color. The outcrop of the limestone is approximately along the line between Baylor and Archer counties. This formation has less of the blue clay and more of the red, with less heavily bedded sandstones, than the Wichita, but aside from the limestone the beds are so irregular in position and distribution that little can be said concerning their arrangement and, unless the appearance of the limestone be taken as a dividing line, no demarkation between the beds can be described. Farther west the Clear Fork is overlain by a series of dark-red and mottled clays with some blue and gray layers all characterized by the more regular bedding, the darker red of the clay (in general), and the presence of large quantities of gypsum in irregular seams, layers of satin spar, and thick beds of massive and semicrystalline character. Gordon found it difficult to distinguish between the Clear Fork and these beds (the Double Mountain of Cummins) and so mapped the two as undifferentiated Clear Fork and Double Mountain.[2] To the author it is as difficult to distinguish between the Wichita and the Clear Fork as it is between the latter and Double Mountain. In following or crossing the line drawn between the two last by Cummins, approximately through Haskell and Vernon, in Texas, a decided change is noticeable in the sediments. This is not to be readily detected in any limited distance or thickness. As far as Haskell the beds are similar to those found east and north of Seymour, that is, they are typical Clear Fork, with a thin but persistent layer of gray or purple conglomerate composed of small pebbles with a considerable amount of cement. This is the layer which I have previously

[1] Cummins, *loc. cit.;* Gordon, *loc. cit.;* Adams, *Am. Jour. Sci.*, XII; *Bull. Am. Geol. Soc.*, XIV.

[2] *Loc. cit.*

described as the Wichita conglomerate north of Seymour. Its persistence and peculiar character make it readily recognizable. Just beyond Sagerton, southwest of Haskell, there is a steep bluff of red clay and shales capped by a heavy sandstone just below which is a thin layer of impure limestone with large-sized, irregular ripple marks. A section taken on the east side of this bluff, locally known as Flat Top, is as follows:

Gray sandstone and fine reddish conglomerate	6–7 feet
Impure limestone, gray, ripple marked	1–2
Red clay with local harder layers and thin seams of gypsum	67
Shaly red clay and bluish clay	12

In the lower beds are some nodules of gypsum and thin layers of satin spar.

These beds are evidently above the Clear Fork and are different in color, in the regularity and persistence of the beds, and in the first occurrence of gypsum in any quantity. Moreover, a careful search failed to reveal any bones; not even fragments in the conglomerate. Cummins found fragments of bones on Paint Creek a few miles southeast of Haskell. The country between Haskell and the exposure just described is very flat or rolling, with a smooth surface and few exposures of the rocks; there is no opportunity, therefore, to determine the line of separation between the Clear Fork and the Double Mountain and I doubt very much whether such a line could be detected in the most favorable exposure. The two series shade into each other so gradually that a sharp line of demarkation does not exist. Double Mountain time was initiated by a slow change in the sedimentation and the climate which resulted in a more regular deposition and for short and irregular periods in a great concentration of the waters. Either of these changes would render the occurrence of vertebrate fossils in the beds much less probable. West of Sagerton the surface of the country is more irregular owing to the occasional breaking-down of the capping layer of sandstone. This is especially true of the breaks on the sides of the Double Mountain Fork of the Salt Fork of the Brazos River. Just before the deeper part of the valley is reached there are several layers of impure limestone which must be considerably higher stratigraphically than the limestone seen at

Sagerton. The stream runs between steep walls of clay with abundant gypsum. On the east side of the stream near the crossing is a bluff from 60 to 70 feet high composed very largely of gypsum with thin intervening beds of gypsiferous clay. No pure selenite was found in this bluff but almost every other form of gypsum occurs: layers of splendid satin spar, impure gypsum in thin and bifurcating irregular seams, as described by Cummins, heavy beds of granular gypsum, and equally heavy beds of clusters of imperfectly formed crystals. From the dip of the beds this is evidently higher than the beds at Sagerton but it is very probable that the increase in the amount of gypsum occurs not only in the rise of the beds but also in their western extension.

Beyond the Double Mountain Fork the surface rock is a loose sandstone of considerable thickness which readily breaks down into a poor sandy soil with very few exposures on the sides of the gentle but pronounced swells. There is considerable gypsum in this sandstone, as shown by the frequent efflorescence and beds of pulverent calcium sulphate. True beds of gypsum do not appear again until the hills beyond Aspermont are reached; here at a much higher level than the gypsum on the banks of the Double Mountain Fork, there occur layers, several feet in thickness, of pure granular gypsum, so soft that it is deeply marked by grooves due to rills of rainwater.

At Double Mountain, a few miles southwest of Aspermont, the following section was made by Dumble and Cummins:

Lower Cretaceous	Caprina limestone	40 feet
	Comanche Peak series	55
	Trinity	25
Triassic	3*a*. Dockum	35
Permian	Shaly clay underlaid by red or terra cotta sandstone	105
	Upper gypsum beds	60
	Middle gypsum beds	75
	Lower gypsum beds	135*

* *Am. Geol.*, 1892, p. 348.

The author's section agrees in only a general way with the portion marked Permian, unless it be understood that the gypsum beds be considered to mean red clay with much interspersed gypsum. Double Mountain is an outlier of the Staked Plains and

shows the easternmost appearance of beds which can be referred to the Triassic. The reference is without paleontological evidence, but there is certainly a bed of disturbed sandstone and sands which fill a gap between the Permian and the Cretaceous. West of Double Mountain the comparatively level surface is continued to the breaks of Blanco Canyon west of Spur in Dickens County. Just east of the point where the road from Spur to Crosbyton crosses the Blanco Canyon there is a small tributary

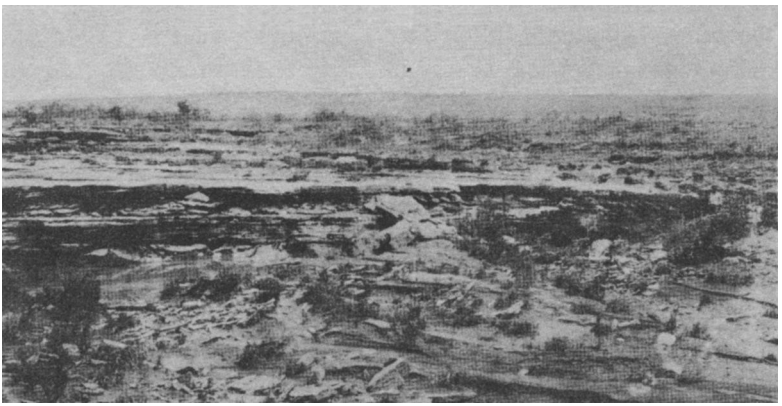

FIG. 1.—Contact between the Dockum (Triassic) and the Double Mountain (Permian) beds near Blanco Canyon. The tilted layer just opposite the figure on the left marks the line of contact.

of the canyon; the road crosses this tributary on a layer of hard, bluish-green sandstone which is apparently near the dividing line between the Triassic and the Permian (see Fig. 1); above it are the sands and clays of the Dockum, as attested by the plant and vertebrate remains, and below it is a break indicated by a stratum of tilted sandstone which in turn lies upon sandstones and clays of the Double Mountain.

A general section of the Triassic at this point is as follows:

Fine cross-bedded conglomerate, variable in thickness	5–20 feet
Red clay shading into yellow above	40–60
White, red, and maroon clay	20–40
Light-brown clay shading into a white clay with gypsum, plant remains, Unio and Triassic vertebrates	10–30
Bluish-green sandstone	3–4
Cross-bedded and tilted sandstone and red clay of the Double Mountain formation	10+

The discovery of Triassic vertebrates in the white clay confirms Cummins' location of the Permian-Triassic line at this point. Just below the bluish-green sandstone which is regarded as the base of the Triassic there is a layer of steeply tilted sandstone which marks a decided disturbance, perhaps of only local significance. Beyond Blanco Canyon the Triassic continues to the base of the Staked Plains and is covered by the Tertiary, the lowest portion of

FIG. 2.—Contact between the Dockum (Triassic) and Double Mountain (Permian) beds on Mott Creek. Above the head of the pick is a light-yellow cross-bedded sandstone; below is a solid red clay.

which is a gravel containing many water-worn shells of Gryphea and Ostrea. The red is again seen in the Blanco Canyon. Where the party descended into the canyon a few miles southeast of Mount Blanco the white Tertiary is underlain by a pink or reddish deposit of clay which is probably of Tertiary age and composed of reworked Triassic material. Below this there is undisturbed red clay, probably of Triassic age, though no fossils were found in it. Beyond Blanco Canyon, in the vicinity of Lyman in Motley County, the

party worked its way into the valley of Mott Creek and followed down the creek to Conleys Peak near White Flat. This creek heads in the Tertiary, producing a very rough topography of characteristic Tertiary bad lands; below this is a wide terrace of coarse gravel and conglomerate carrying water-worn Cretaceous fossils. Below the terrace is a series of red clays and sandstones, the latter much cross-bedded and disturbed; in certain local layers of limy

FIG. 3.—Triassic beds on Salavito Creek. Gray clays and sandstones capped by heavy gray and red sandstone.

material Unios and fragments of Phytosaur bones were found in the sandstone, determining the Triassic age of the beds. On descending Mott Creek the disturbed Triassic beds are seen to lie upon a series of red clays, very dark in color and evenly bedded, very similar in appearance to the Double Mountain beds farther east and south. The physical characters are far from being a dependable character for correlation in the Red Beds, but taken in connection with the sudden change in character, the striking unconformity, and the correct stratigraphic position these are very probably the same, Double Mountain, beds as seen east of Spur.

From Mott Creek the party again ascended to the surface of the

Staked Plains at Quitaque and then made its way to Clarendon across the Red River, or the Prairie Dog Fork of the Red River, as it is marked on the maps. This region has been described by Gould in *Water Supply Papers 154* and *191* and needs no further description. It appears to me from our section and almost continuous tracing of the beds that there can be no doubt that the horizons called Quartermaster and Greer in the eastern and western portions

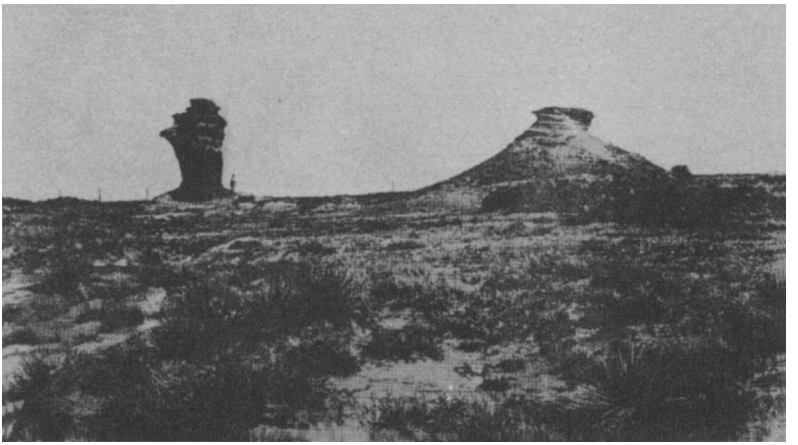

FIG. 4.—Triassic beds in the Bad Lands of Trujillo Creek, east of Tucumcari. The capping sandstone and conglomerate is the same as that which forms the surface of the shelf extending north from the foot of the Staked Plains.

of the Panhandle by Gould are the same as the Double Mountain beds farther south.

From Clarendon the party went to Amarillo and then followed the Chicago, Rock Island & Gulf Railroad across the Staked Plains to the western edge. Here the red again appears in irregular beds of sandstone and varicolored clays extremely irregular in thickness and extent but carrying Phytosaur bones wherever seen. In the breaks of the small Arroya Salavito just beyond Endee in Quay County, New Mexico, the beds are even more than ordinarily complex, massive white and gray sandstones lie above cross-bedded white and gray sandstones and clays, but here again fragments of Phytosaur bones and teeth were found. The main object of the

trip from this point west to the mountains was to detect any recurrence of the Permian Red Beds, but, as will be shown, nothing below the Triassic was found.

Farther west the breaks of San Juan Arroya or Trujillo Creek are locally known as the Bad Lands; here there is a very considerable exposure of Red Beds. The beds, as in Salavito Arroya, are considerably below those which are exposed in the bluff forming the

FIG. 5.—Larger view of the pillar shown in Fig. 4. The light-blue layer of sandy clay is seen just below the conglomerate cap. Below is red clay.

western edge of the Staked Plains a few miles to the south. A layer of heavy sandstone and conglomerate, varying rapidly in character, but as a whole very persistent, determines a shelf extending north from the foot of the plains and covered with grass. It is only in the valleys of the streams that it is broken through and the lower part of the section exposed. A short distance to the north the streams run out upon the shelf which is not again broken until the breaks of the Canadian River to the north are reached. A

section of the upper portion of the Triassic taken on the west side of the plains just west of Adrian is as follows:

Tertiary marl	6–20 feet
Fine white sandstone	20
Red clay	10
Red sandstone or hard sand	12–15
Dark-red clay containing a layer of variable sandstone and conglomerate	20+

It is the conglomerate at the base of the section which forms the top of the shelf described above; it rises and falls in the layer

FIG. 6.—Variegated clays of Triassic age in the Bad Lands of Trujillo Creek. The remnants of the conglomerate cap may be seen. The clays are red, purple, and light orange.

of clay and changes its character very suddenly, being strongly reminiscent of the conditions in the Clear Fork beds. In the breaks of the streams mentioned above the conglomerate forms the top of the section. A general section in the Bad Lands of Trujillo Creek is as follows:

1. Conglomerate (top). Grayish in general, but locally reddish and overlain by red sandstone in places. The pebbles variable in size and character. Some thin layers of clay and shale. In places replaced by sandstone (in one place a true arkose).

2. Thin, blue, sandy clay; very persistent just beneath the conglomerate and frequently much distorted, apparently by local movements due to pressure. From 6 to 12 inches thick.

3. A heavy bed of red clay of varying shades and some blue streaks. Generally very homogeneous but with some layers of calcareous material. Near the bottom some shaly layers with worm casts. Two hundred and fifty feet thick, more or less.

4. A second series of sandstone and shaly layers. Bottom not seen, but Triassic bones to bottom of exposures.

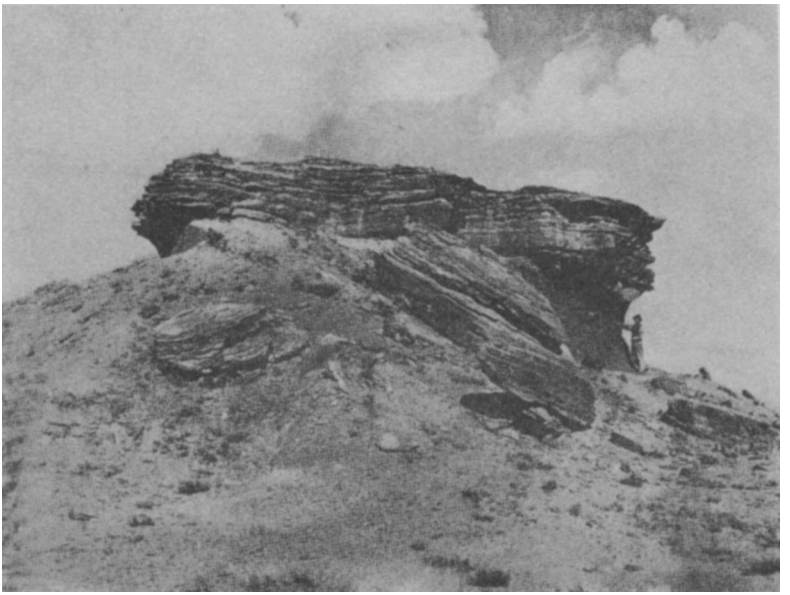

FIG. 7.—A remnant in the Bad Lands of Trujillo Creek. Just below the conglomerate cap may be seen the layer of bluish sandy clay, just over the figure. Below the bluish layer the clay is purple, which shades downward into bright red.

The lower beds may be traced to Tucumcari and Montoya, the road lying upon the shelf described above. At Mount Tucumcari and in the magnificent section seen in Bull Canyon, just south of Montoya, it is the upper portion of the Triassic which is exposed. A slight anticlinal fold at Montoya brings some of the lower beds to the surface, but even here Phytosaur bones were found in the lowest exposures.

From Montoya the route of the party led along the foot of the mesa to the head of the Conchas River. The sandstone or con-

glomerate followed from farther east forms the floor of the valley; the upper part of the Triassic is exposed in the walls of the mesa beneath the capping of Dakota Cretaceous and the Morrison formation (Lee), and the lower part is seen in the valleys of the streams. Beyond Cabra Spring (a single ranch house located near the middle of the Corazon Topographic Sheet) the Conchas River

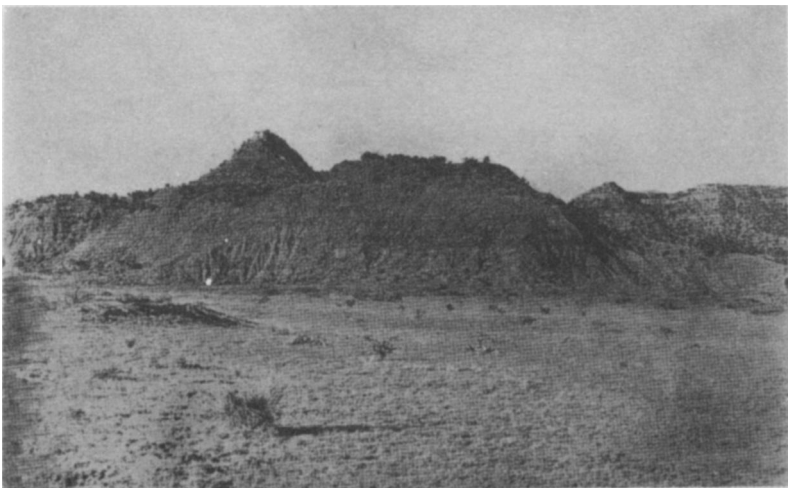

FIG. 8.—Red clay in the walls of Bull Canyon just south of Montoya. This is the portion of the Triassic above the conglomerate layer which forms the shelf extending north from the foot of the Staked Plains.

has cut a deep gorge through the heavy sandstone and conglomerate into a heavy bed of white sandstone (40–50 feet) of a local character. Beneath and partly within this sandstone is a lense of dark-red and mottled clays and shales, much distorted and streaked with greenish clay and a greenish conglomerate of small pebbles. This is the lowest bed of the Triassic that was seen and it so much resembles the Double Mountain that I at first thought that it must be Permian; but the discovery of Unios in the layer of greenish conglomerate revealed its Triassic age. This makes it altogether probable that nothing below the base of the Triassic appears between Montoya and Las Vegas.

Ascending to the top of the mesa by the difficult road at the

head of the Conchas Canyon, the party proceeded to Las Vegas Hot Springs. Here the red again appears in vertical layers on the edge of the mountains. This class of exposures is obviously an exceedingly unfortunate one in which to search for vertebrate fossils. The Red Beds had been lost when we ascended to the top of the mesa from the Conchas Canyon, but the nearly horizontal

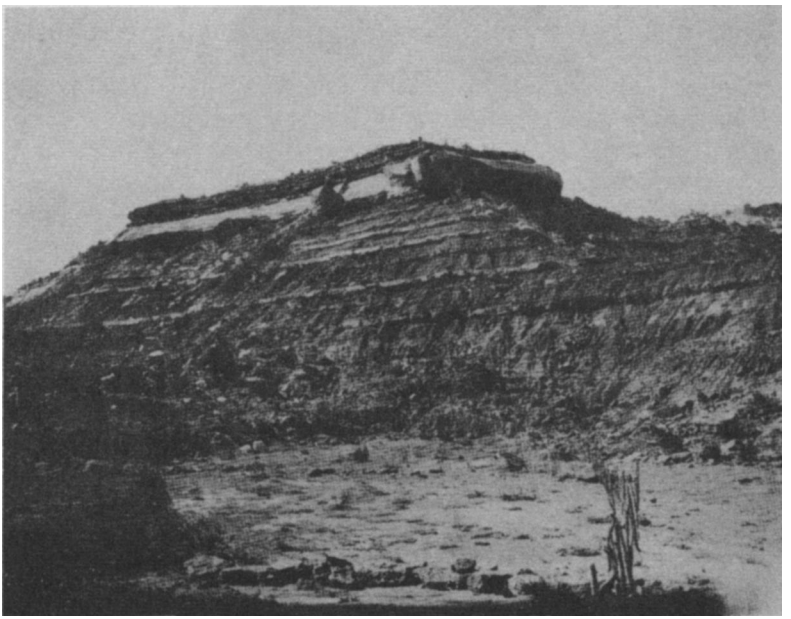

FIG. 9.—Clays, sandstones, and impure limestones in the wall of Bull Canyon just south of Montoya. Contrast the horizontal condition of the beds in this the upper portion of the Triassic with the disturbed condition shown in the lower beds (FIG. 3).

condition of the beds in the sides of the mesa and the Cretaceous cap leave little possibility of doubt that the beds turned up on the sides of the mountains at Las Vegas Hot Springs are the same as those we left a few miles to the east. On the Geological Map of the United States the Red Beds on the flanks of the mountains are called Permian. Girty examined the beds at Las Vegas Hot Springs but was unable to determine their age. A day's careful search by the author in the vicinity of Las Vegas Hot Springs

resulted in the finding of a single broken tooth in a conglomerate near the middle of the series; as this is a Phytosaur or Dinosaur tooth it shows that the upper half of the beds, at least, is Triassic. Whether any of the beds below this belong in the Permian it is still impossible to say, but when we consider the great thickness of the Triassic not very many miles to the east it is not likely that Red Beds of Permian age have any considerable thickness, if they are present at all. Moreover, it can be shown that the Permian beds

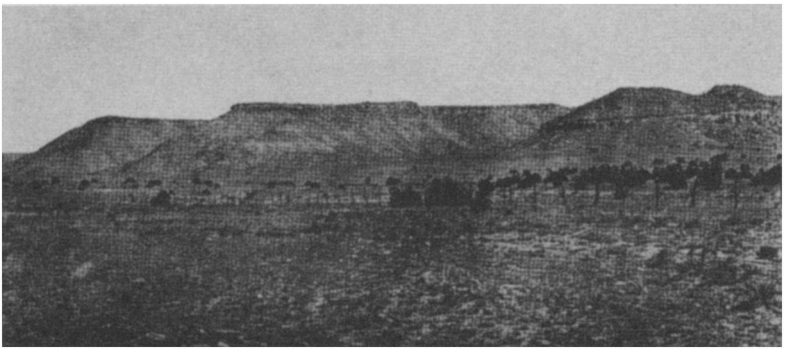

FIG. 10.—Wall of the mesa near the head of the Conchas Canyon. The capping layer is Dakota beneath which lie the beds considered by Lee as Morrison. The lower heavy layer is the uppermost layer of the Triassic.

north of Santa Fe were laid down in an area of deposition completely separated from that over Texas and Oklahoma. I am inclined to suggest that the sea or area of deposition which covered northern and western Texas and Oklahoma had its western border somewhere east of the present Rockies and that the Red Beds on the eastern flanks of the mountains in northern New Mexico and southern Colorado, at least, have no Permian members.

It will be seen from the foregoing that the evidence from vertebrate fossils bears out in a pretty conclusive manner the conclusions drawn from stratigraphic evidence. The Clear Fork beds, with their vertebrate fauna, disappear beneath a distinct set of beds, the Double Mountain, at about the line of Haskell. Just how much farther west they go it is impossible to say, but it is not far. In western Texas and eastern New Mexico, along the line followed,

they are deeply buried beneath the Triassic and most probably do not appear on the flanks of the Rockies. The change from the Clear Fork to the Double Mountain was a very gradual one but sufficiently profound to render the presence of fossils in the beds or of animals in the region during the time of deposition (the two things are very different) almost impossible.

The contact between the Triassic and the Double Mountain is marked in several places by sharp unconformities, but the beds are

FIG. 11.—Vertical beds of Triassic age on the south side of the small valley at Las Vegas Hot Springs.

so irregular above and below that it is impossible to evaluate the unconformity. It is certain that after a period of erosion or exposure conditions of sedimentation closely resembling those of the Clear Fork followed the more uniform conditions of the Double Mountain. That this interval was long is suggested by the totally new fauna contained in the beds, but this is not conclusive. The fauna may have been evolving during the Double Mountain time or may have started even earlier and reached this region by migration at the beginning of the Triassic.

The sediments of the upper part of the Permian were undoubtedly derived from some not very remote land mass but the outlines

of this cannot as yet be suggested. Undoubtedly the Wichita Mountains furnished much of the sediments of the Texas and Oklahoma beds, but where the western land mass lay and what were its limits are yet uncertain. Many suggestions have risen as to its possible outlines but the discussion of the evidence is beyond the limits of this paper.